Met Office Upper Stratospheric and Mesospheric Analyses: Validation and Improvement of Gravity Wave Drag Scheme

Submitted by

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to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Mathematics, February 2011.

I certify that all material in this thesis which is not my own work has been identified and that no material is included for which a degree has previously been conferred upon me.

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Abstract

The global analysis fields of the Met Office stratospheric assimilated data set have been investigated. Systematic biases for select years were identified through validation with independent satellite observations. Particular attention was given to analyses from January 2005 to October 2009 produced from a 50 level (L50) configuration of the UM with model lid at ~0.1 hPa, and the impact on analyses fields from November 2009 to September 2010 when the middle atmospheric configuration of the UM was extended to ~0.01 hPa using 70 levels (L70).

Validation results from both the L50 and L70 analyses show that largest temperature biases occur at polar latitudes approaching the model lid in the mesosphere, exhibiting a clear seasonal cycle. Here cold biases in the winter season of the L50 analyses and warm biases in the summer season of the L70 analyses would strongly suggest that the mean meridional circulation in the mesosphere is underestimated, and that small scale gravity wave forcing supplied by the operational Ultra Simple Spectral Parameterisation (USSP) scheme is insufficient.

Based on the above validation results numerous experiments were conducted to investigate the temperature response in the mesosphere to increased gravity wave forcing. Such experiments concentrated on tuning the energy scale factor (β) in the USSP scheme and the application of a momentum conserving "opaque" lid. Furthermore, the impact of developing the USSP scheme to include direct heating from gravity wave induced turbulent dissipation was also investigated. Maximum temperature responses in the summer polar upper mesosphere of ~22

K were found when increasing the standard value of β=0.1 to β=0.14 combined with the application of an opaque lid. Magnitudes of direct heating rates due to gravity wave turbulent dissipation diagnosed via the USSP scheme were found to be consistent with previous estimates. However applying such heating would most likely have a negative impact on the L70 analyses, which already display warm biases in the upper mesosphere, strongly suggesting that additional physical processes such as eddy diffusion must also be accounted for when applying direct heating from gravity wave breaking.

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